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ON THE IMPULSE FOR THE FORMATION OF FLOWERS.

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As early flowering means an early crop, it is sometimes desirable to bring this about. This is especially important in Porto Rico with citrus fruits. An early crop of grapefruit and orange will reach the northern markets in the fall before those of Florida and California are ripe. In this connection the following notes on the flowering of plants should prove of value indicating the best means available to bring this about.

Since the raising of crops means in most cases the formation of flowers and fruits and as there exists a correlation between the production of leaves and the production of flowers, it is a question of great importance which circumstance gives the impulse for the formation of each. Many observations indicate that flowering is brought about by a rise in the concentration of sugar in the cell sap which causes the differentiation of a cell into the different parts of a flower generative development.

The plant is ruled by three primarily chemical processes, which are followed by numerous secondary transmutations; namely: formation of sugar, formation of protein, and respiration process. The sugar produced in the chlorophyll bodies is at once partially turned into starch and partially transported to the roots and new branches to enable the formation of the cell wall and of the protein for the protoplasma of the new cells. Whenever there becomes more sugar available than is necessary for the needs of the new organs, it is partially transformed into transitory or secondary starch which is again dissolved when sugar is needed. However, a leucoplast must be present for the formation of each starch granule.

In the cell sap of every growing plant some sugar is present and it has been observed for a long time with cereals that their cell sap shows the highest content of sugar at the time of flowering. The more favorable the conditions for protein formation the more the growth of young branches and leaves will be enhanced. Hence, the experience of growers that a rich nitrogenous manuring favors more the formation of new branches and leaves than of flowers is well sustained by physiological principles.

Whenever a plant is observed flowering before it has reached its normal growth, we may be certain that either the amount of available nitrogen was insufficient or that the root was injured and thus rendered incapable of absorbing a sufficient amount of nitrogen. I once observed a buckwheat plant of but 12 cm. in height that had two flowers. The examination of the root demonstrated that more than half of it had been eaten by insects. The principle of forcing a plant to flower by preventing growth has been applied in olden times by Japanese gardeners, who clip the roots at a convenient time. Thus they succeed in producing, for example, orange trees on only 40 cm. in height that flowered and born ripe fruit.

Again, there exist plants that use for many years all the sugar produced by the chlorophyll bodies for secondary starch production and vegetative growth before a flower makes its appearance. The bamboo, for instance, may reach its normal height in one year, but it uses its sugar continuously for developing rhizomes from which new shoots are starting. Once in 15 to 25 years flowering will set in and in such luxuriant measure that with the ripening of the seeds the plant dies, the seeds having absorbed all possible organic and inorganic nutrients from leaves and trunk.

With cherry trees it has been observed that branches infected by the fungus parasite Exoascus bear no flowers or only very few, since the fungus absorbs much sugar for its respiration and growth. If, however, a wire is tied around the base of the branch preventing the migration of the surplus sugar into the trunk, a considerable flower formation will make its appearance. It has been observed that mulberry trees with leaf sprouts killed by frost developed afterwards numerous flowers. The sugar derived by diffusion from the killed leaves increased the sugar concentration in the trunk, giving the impulse for flower formation.

An increase of flower formation may follow a rise of temperature when at the same time there is no added moisture. The flowers appear when the evaporation from the plant leads to an increase of the sugar concentration. Certain trees which form flowers in a temperate climate, show in the moist tropics no flowers but a luxuriant vegetative development. Trees which easily flower in the climate of Berlin will show less flowers but more leaves in the moist climate of Hamburg. The increased rains probably furnish sufficient nitrogen for the enhancement of the vegetative growth. This may be observed with potato plants, which show many more flowers in dry summers with much sunshine than in cloudy and rainy summers.

It has been observed that a tree standing to the northside of a building in such a manner that half was exposed to the direct sun rays while the other half was covered by the shade of the building, showed numerous flowers in the direct

sunlight, while but very few in the shade. In this case the formation of sugar by the chlorophyll bodies was much promoted by the increased amount of light. It has been noted by H. Fischer that a plant kept in yellow light produced more flowers than in blue light. It is well known that the yellow and red rays favor the assimilation of carbonic acid more than the blue ones. Recent observations have further noted that plants kept in an atmosphere rich in carbonic acid show a considerable increase of flower formation. Generally the point of flower formation is reached when the absorbed nitrogen is nearly consumed or the vegetative growth is slowing down. But there are cases where flowers are formed at the same time with rapid growth. Such plants produce evidently such a great amount of sugar that it can suffice to give continuously the impulse for flower formation.

But there is required still another condition for the formation of flowers; that is, the presence of a sufficient amount of phosphoric acid, which enters into action when the vegetative development is slowing down. This fact has been demonstrated by an experiment which I had carried out with the assistance of Takeuchi at the University of Tokyo. A sand culture was prepared of upland rice, four plants per pot containing four kilos purified sand. The general manure consisted of potassium sulphate 0.5 gram, ammonium nitrate 1 gram, ferric hydroxide 0.25 gram, sodium chloride 0.05 gram. Lime and magnesia were supplied as fine powders, passed through a 0.25 mm. sieve, in the form of limestone 5.36 grams and of magnesite 6.25 grams per control pot. The phosphoric acid was applied as secondary calcium phosphate, 5.63 grams in the control pot. In two cases the amounts of lime and magnesia were increased, in other two cases the amount of phosphoric acid.

The following table shows the ratios of lime to magnesia and to phosphoric acid as well as the yields:-

	CaO	MgO	P_2O_5	Average height of stalks - cm.	Weight of straw - grams -	Number of ears.	Number of grains.	Weight of grains - grams.
a)	1	1	1	74	5.63	4	108	2.0
b)	5	5	1	68	5.22	none	none	0
c)	1	1	5	75	6.48	5	151	3.3
d)	5	5	5	70	6.70	3	41	0.95

Since the nitrogenous manure was present in equal quantity in all four cases, the height of stalks and the weight of straw do not show great differences, while the number of seeds differed in a very marked degree. Where the amount of phosphoric acid was greatest and the depression of its availability by lime was smallest, namely, in the pot (c), the amount of seeds was greatest. But where the amount of phosphoric acid was smaller and its availability depressed by the increase of lime, the formation of ears and flowers was entirely suppressed. The great difference between 151 seeds in pot (c) and none in pot (b) is indeed surprising and decisive.

With the increase of lime also the higher dose of phosphoric acid in the form of secondary calcium phosphate became less effective, as will be seen with the result in pot (d) compared with pot (c). The experiment was repeated with essentially the same result. It demonstrates clearly that phosphoric acid plays an essential role in the impulse for flower formation. If as in pot (b) the amount of phosphoric acid required for vegetative development is not sufficient to influence the formation of flowers, the amount must be increased.

To resume: The production of protein furthers the formation of new branches and leaves. A certain increase of sugar in the plant sap gives the impulse for the formation of flowers, but a certain amount of phosphoric acid is required to render this impulse effective.

These physiological laws should be taken into consideration in manuring different crops. The best ratio of phosphoric acid to nitrogen established for fruit crops is not adapted to leaf crops as tobacco and tea, where the flower formation is suppressed in favor of leaf production. The nitrogenous manure must be here very considerably increased relative to the phosphatic manure. This holds good also for plants cultivated for their fibres, viz., hemp and flax.

When tree plants are cultivated for fruits only, then it will be advisable to prevent a too luxuriant development of new branches and leaves; the nitrogenous manuring should be reduced, and newly formed branches cut away. Thus the sugar concentration in the sap of the tree will be increased, leading to a satisfactory flower formation.